FEDERAL EXPERIMENT STATION IN PUERTO RICO
of the
UNITED STATES DEPARTMENT OF AGRICULTURE
MAYAGUEZ, PUERTO RICO

REPORT OF THE FEDERAL EXPERIMENT STATION IN PUERTO RICO 1950

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FEDERAL EXPERIMENT STATION IN PUERTO RICO

Mayaguez, P. R.

Administered by the Office of Experiment Stations, Agricultural Research Administration, United States Department of Agriculture

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Report of the Federal Experiment Station in Puerto Rico, 1950

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INTRODUCTION

During the past year the station has continued investigations with crops of strategic and economic importance to the continental United States and Puerto Rico. The more basic and fundamental phases of this research have been emphasized and new personnel has been selected during the year with this emphasis in mind. Some of the projects dealing with crops that were of importance during recent years have been temporarily curtailed in favor of more active and promising investigations.

Cooperative work with other agencies of the Department, particularly the Bureau of Plant Industry, Soils, and Agricultural Engineering, has yielded results of considerable importance to United States producers of fruits and vegetables of tropical and subtropical origin. The ability to induce flowering and make crossings not possible under continental conditions has generally speeded up the breeding programs for crops like cotton, sweetpotatoes, etc. The cooperative programs on forage improvement and weed control conducted under Research and Marketing Act funds are other outstanding examples of cooperative efforts.

The appropriations made for physical-plant improvement have contributed directly to the quality of the research program. The new buildings have, in many cases, provided badly needed space and facilities and have made other indirect contributions to the maintenance of high morale and good production.

The Insular Government has continued to give its support to the station activities, and even though the appropriation made is relatively small, it has helped materially to support the over-all research program, particularly work on tropical crops of local interest.

This publication presents a summary account of the accomplishments of the Federal Experiment Station in Puerto Rico during the fiscal year 1950. It is hoped that many of the fundamental studies reported may lead to practical applications in temperate and tropical agriculture.

PERSONNEL

The following changes occurred in the Federal staff during the year. Thomas J. Muzik was appointed plant physiologist on October 1, 1949. Héctor J. Cruzado was transferred from agronomist under Insular funds to scientific aid under Federal funds effective January 29, 1950. Edward P. Hume resigned as horticulturist on September 13, 1949, to accept a position at the University of Vermont, and Roberto Ferrer Delgado resigned as scientific aid on December 10, 1949.

The following changes occurred during the year in the personnel employed with funds provided by the Government of Puerto Rico. Rafael Fernández Pol resigned as chemist on September 13, 1949, and Jean García Rivera was appointed to fill the vacancy on December 1, 1949.

COOPERATION WITH OTHER GOVERNMENT AGENCIES

The Government of Puerto Rico appropriated funds in the amount of $45,000 to the Federal Experiment Station for carrying out cooperative experimental work on agricultural problems of particular local interest. These investigations included studies on vanilla, spices, weed control, essential oils, and bamboo.

The Experiment Station of the University of Puerto Rico and the Federal Station continued to maintain close cooperative relations. The tomato, papaya, and forage improvement projects were continued. Through conferences of staff members, the two stations maintained a well-coordinated program. The Federal Station provided office, laboratory space, and land facilities for the experimental work with coffee being conducted by the Insular Station at Mayaguez.

The College of Agriculture and Mechanic Arts of the University of Puerto Rico, located adjacent to the station, utilized station facilities for their field demonstrations. During the summer vacation, three students completed a practice course of study at the station in the fields of horticulture, genetics, and chemistry.

The Extension Service of the University of Puerto Rico was extremely helpful in the distribution of plant material to farmers, and in the dissemination of technical information obtained by the station.

The Federal and Insular Forest Services made labor available to the station for the propagation and distribution of newly introduced bamboos. Owing to a shortage of funds, this work was discontinued at the end of the calendar year 1949. Several thousand bamboo offsets were planted in the forests of Puerto Rico as a result of this program. The Forest Service continued to make land available to the station at Toro Negro, Maricao, and Guanica, for the testing of various tropical plants.

The Puerto Rico Industrial Development Company cooperated with the station through the distribution of cured bamboo culms for industrial purposes.

A number of cooperative projects were carried out in cooperation with other bureaus and agencies of the Department. The work with cotton, started last year in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Texas Agricultural Experiment Station, was continued. A number of selfings and crosses of tropical and subtropical cottons of potential value for improving domestic varieties were made. Fundamental studies on rubber were expanded to some extent during the year, and interesting data on flowering and pollination of rubber plants were obtained. An investigation on the improvement of sweetpotatoes and the introduction of varieties resistant to fusarium wilt was also carried out in cooperation with the Department bureau.

Office space was provided the Soil Conservation Service. The Soil Erosion and Stable Crop Control Project, supported by the Research and Marketing Act funds, utilized office, laboratory space, and land, provided by the station through June 1949, at which time the headquarters of the project were moved to the Experiment Station at the University of Puerto Rico, Rio Piedras. Office space was also made available to the Farmers' Home Administration up to September 1949. The Bureau of Entomology and Plant Quarantine was provided with office and laboratory space for one of their Plant Quarantine inspectors, and office space was also provided for the cooperative inspector of the Insular Plant Quarantine Service.

Close relations were maintained with the Office of Foreign Agricultural Relations of the Department in the exchange of technical information and plant material. The cooperative bamboo experiments initiated last year in collaboration with F. A. McClure, Field Service Consultant on Bamboo for the Office of Foreign Agricultural Relations, were continued.

Through the cooperation of the Agricultural Research Administration an intensive series of lectures on statistics was presented by E. L. LeClerg. The course was well attended not only by members of the station staff but also by the staff members of the University Station and the College of Agriculture.

The Mexican Government assigned an entomologist to work at the station for a period of approximately 5 months on a study of the methods of biological control of the sugarcane borer.

Individuals and various companies too numerous to mention have extended cooperation in many ways. Through the cooperation of many agencies and individuals scattered throughout the world, many additions have been made to our extensive collection of tropical plants.

PHYSICAL PLANT IMPROVEMENT

Funds were appropriated for 1950 for the construction of a reinforced concrete building to provide garages and warehouse space and to replace old wooden structures in the area known as the Cuadra. The new building is located on a partly excavated hillside and provides garage space and repair facilities for trucks and tractors as well as for boiler and incinerator installations. The upper level is divided into several rooms, including carpentry, plumbing and paint

shops, rooms for the storage and preparation of herbicides and insecticides, grinding and drying rooms, and laborers' toilets. The new building will be connected to two existing concrete buildings and will form a compact unit. A reinforced concrete slab roof will be poured for the entire unit.

The laboratory formerly occupied by personnel of the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Soil Conservation Service on the Soil Erosion and Stable Crop Production Project was vacated in June when the headquarters of this project was moved to the Experiment Station of the University of Puerto Rico at Rio Piedras. This space was converted into a cytology laboratory and offices for the plant breeding group of the station. The laboratory formerly used for vanilla curing and chemistry was converted into offices for the weed control group and a laboratory for use in morphological and tissue culture studies.

Space was partitioned off with concrete blocks between the two main chemistry laboratories to form a small room which accommodates a 12-unit Kjeldehl digesting and distilling apparatus, muffle furnace, and drying ovens.

A greenhouse formerly maintained for the purpose of plant quarantine was reconditioned to provide facilities for pathological investigations.

The sewage system was completed so that the new building in the Cuadra and the director's house are now connected to the city system. All of the main station buildings are now connected to the city sewage disposal.

INSECTICIDAL CROP INVESTIGATIONS

Selection of Derris Clones. R. H. Hageman and C. Pagán.

Two major introductions of the Sarawak Creeping variety of *Derris elliptica* (Wall.) Benth. have been made at this station, one consisting of 34 cuttings from Rio Piedras, P. R., and the other of 434 cuttings from Summit, Canal Zone. A recent study of the Sarawak Creeping variety in which the toxic constituents were estimated from total chloroform extractives, showed a greater divergence in values than was shown in clonal material of another variety. This variation suggested the possibility that more than one clone might be present in the population of Sarawak Creeping plants at this station.

A project was started to select plants with the highest rotenone content. The roots of these plants were evaluated on the basis of their total chloroform extractives and rotenone and rotenone equivalent of 50 plants evaluated were calculated by use of equations. Twenty-six were above average in toxic constituents. Eight plants of this selected group had exceptionally high rotenone content with values ranging from 8.3 to 10.6 percent. A second set of plants selected at random from the same location is now being studied to determine whether a similar segregation will be obtained and also to provide an additional source of propagating material from the higher-yielding plants.

Derris Flowering. R. H. Hageman and H. E. Warmke.

Both trellised and untrellised plants of all MG clones of *Derris elliptica* Changi III flowered profusely during April and May of this

year. Only one plant, however, formed seed pods. This was a plant of the MG–2 clone. It set three seed pods, but two abscised soon after formation. The remaining pod was bagged but failed to produce viable seeds.

DERRIS AND LONCHOCARPUS PROPAGATION. R. H. Hageman and C. Pagán.

Since there is an observable relationship between the growth flushes of *Derris* and the rainy periods, it was thought that this influence might also be reflected in the propagation of cuttings. An experiment was conducted to determine the effect of propagating *Derris elliptica* varieties Sarawak Creeping and Changi III MG clones in different seasons. Plantings were made in February, May, August, and November. These dates were selected because the period May to November represents the season of heaviest rainfall and the period November to February the season of lightest rainfall.

The difference in the effect on propagation of taking the cuttings of the two varieties at different times was quite marked. Sarawak Creeping cuttings did not survive when propagated in August, but survived satisfactorily when planted at the other dates; on the other hand, the survival of the Changi III MG clones was uniformly high regardless of the cutting.

In a similar experiment with *Lonchocarpus* sp., cuttings propagated equally well regardless of the time they were taken. Survival was uniformly high for all cuttings.

BIOASSAY OF DERRIS AND LONCHOCARPUS. R. H. Hageman and C. Pagán.

The guppy method developed at this station for biological assay of insecticidal plants is not satisfactory for evaluation of low rotenone content. The amount of root powder has to be increased to bring the material to a minimum toxicity point. This produces a mixture containing variable amounts of rotenoids of unknown toxicity. To correct this condition, the original method was modified and comparisons were made (1) with test solutions prepared by weighing varying amounts of root powder so that the final concentration was 0.10 p. p. m. of rotenone, and (2) with test solutions prepared by weighing the same amount of root powder and adding pure rotenone to bring the rotenone concentration to 0.10 p. p. m.

The data showed that in samples of 2.5-percent rotenone the value of toxicity was the same regardless of the method; however, as the percentage of rotenone dropped the error increased significantly. In such cases the addition of an amount of rotenone sufficient to bring the toxicity level of the sample to the toxicity threshold gave a more accurate measure of rotenone equivalent, and at the same time facilitated statistical treatment.

CHEMICAL STUDIES. C. Pagán and R. H. Hageman.

An attempt was made to isolate compounds in derris root that might be precursors of rotenone. It was thought that periodic determination of rotenone and related compounds during the early growth of the roots might give some idea as to the biosynthesis of rotenone. Root samples for the first analysis were taken when the plants were 2 months old and succeeding samples were taken at monthly intervals thereafter over a 5-month period.

Chemical evaluation of the samples included determination of rotenone content, neutral resin, alkali-soluble fraction, and fats and waxes.

An unknown compound having a reddish color was also isolated and measured semiquantitatively. The neutral resins and the alkali-soluble fractions were considered as rotenoids. In the 2-, 3-, 4-, 5-, and 6-month roots of the Changi III MG variety, the rotenone content was 0, 1.8, 4.6, 5.3, and 4.8 percent, respectively. By contrast the Sarawak Creeping variety required up to 14 months to attain an equal rotenone content.

After the first harvest the rotenone and rotenoids increased proportionally. The formation of rotenone and rotenoids was parallel. Although the rotenoids were deposited first, the formation of rotenone proceeded at a faster rate as the plant grew older. This indicated that an equilibrium between the rotenone and rotenoids was established in mature plants.

It has been assumed that the toxic resins of derris are deposited as a suspension of oleo resins. In this work no proportional increase in the fats, oils, and waxy fraction was observed although the rotenone content increased from traces to 5 percent.

The "red compound" showed an entirely different pattern of deposition from the other fractions. It was the only compound besides rotenone not found in the 2-month-old roots. However, in subsequent harvests both compounds were present although not in proportional quantities.

Preliminary tests indicated that this red compound has properties resembling the anthocyanins. Since anthocyanins in general have a flavon group similar to that of the rotenoids, these observations suggest that the red compound may be a precursor or related in some way to the synthesis of rotenone.

Total chloroform extractives gave a better idea of the rotenone content and rotenone equivalent than any of the other constituents. This indicated that even in very young derris plants total extractives were the best criterion for measuring rotenone content and toxicity.

Bioassay for DDT. C. Pagán and R. H. Hageman.

The widespread use of the insecticide, DDT, has brought about the problems of the residue of this compound in milk and other foods. A biological method in which guppies are used as the test animal for determining the toxicity of certain insecticidal plants was modified to adapt it for determining small amounts of DDT. Preliminary trials using technical DDT in water were made to establish the toxicity range. The lower limit of sensitivity when the most susceptible fish were used was around 0.025 p.p.m. which produced a kill of approximately 15 percent in 24 hours.

When diluted milk contaminated with DDT was used as the test media, erratic results were obtained. The milk fat in some way slowed down the rate of penetration or poisoning action of DDT. This necessitated extending the exposure time to 48 hours with the result that the controls had a high mortality. The inconsistent results obtained with prolonged exposure in milk indicated that some factor other than the DDT was also toxic to the fish. This was substantiated by the fact that on the occasions when the mortality in the controls was low the kill obtained in the treated samples was proportional to the concentration of DDT. Bacteriostatic and surface active agents, aeration, and homogenization were of no benefit in producing consistent results.

Although the test as such could not be applied to determine the residue of DDT in milk, its high sensitivity and simple technique may be found useful in other aspects of DDT toxicology. A practical application of this technique was developed for the determination of DDT residues on vegetables. A 0.1-percent solution of wettable DDT powder (50 percent) was applied to whole fresh tomatoes and beans. The samples were allowed to stand for 1 hour, extracted with acetone, and the extracts were then tested on the fish. The results showed good recoveries for all concentrations in both vegetables, with an error within limits of biological methods.

DRUG-CROP INVESTIGATIONS

NURSERY TREATMENTS. H. F. Winters.

Three fumigants were tested for effectiveness against soil-borne diseases of cinchona nurseries: (1) Larvacide (99 percent chloropicrin), at the rate of 300 pounds per acre; (2) D–D mixture (1,3-dichloropropene, 1,2-dichloropropane, 100 percent), 300 pounds per acre; (3) ethylene dibromide, 300 pounds per acre; and (4) control, no treatment. The fumigation chemicals were all applied as liquids by injecting 2 cubic centimeters into holes at 8-inch spacing and two-thirds the soil depth of 6 inches.

At 6 months of age, plants under the chloropicrin treatment were larger and more thrifty than plants in other treatments. The plants in this treatment were ready for transplanting to the field after 6 months in the nursery, but plants in the other treatments were not ready before 9 months. At 9 months, plants under the chloropicrin treatment with an average height of 24.1 inches were far superior to those in the check plots with an average height of 14.7 inches. The difference between the chloropicrin treatment and the other treatments was highly significant.

The extent of growth and survival as measures of vigor and freedom from disease was studied. Plants given the chloropicrin treatment were outstanding in growth and their rate of survival was higher than in plants given any of the other treatments.

CHEMICAL STUDIES. A. J. Loustalot, C. Pagán, and H. F. Winters.

An experiment was initiated in June 1946 to study the relationship between size, age, and parts of young *Cinchona* trees and their total alkaloid and quinine content.

With some exceptions, the results of the 1949 analyses in general were similar to those of the three previous years. There was no consistent correlation between vigor as measured by height of tree and total alkaloid and quinine content. The percentage of quinine in the lower trunk bark varied from 5.49 percent to 2.70 percent and in the upper trunk bark from 4.18 percent to 1.67 percent. There was no consistent correlation between the amount of quinine in the roots and upper trunk bark and that in the lower trunk bark. The quinine content of all tissues was somewhat higher in 1949 than in 1948. The concentration of total alkaloids in the roots was not always correlated with that in the lower trunk bark and other tissues. The percentage of total alkaloids was about the same in all tissues in 1949 as it was in 1948.

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FOOD-CROP INVESTIGATIONS

SWEETPOTATO FLOWERING. H. E. Warmke and H. J. Cruzado.

Four additional varieties of Jersey-type sweetpotatoes were brought to flower in field plots during the winter of 1949–50. These are Red Jersey, Vineland Bush, Big Stem Jersey, and Jersey Orange, and bring to seven the number of Jersey varieties now in flower at Mayaguez (including the three varieties Orange Little Stem, Maryland Golden, and Yellow Jersey, previousy reported). These varieties are being intercrossed among themseves and with moist-flesh varieties known to be resistant to fusarium wilt.

SWEETPOTATO BREEDING. H. E. Warmke, H. J. Cruzado, and E. Vivas.

During the year 254 seeds were produced from crosses between moist-flesh and Jersey-type sweetpotatoes. This is more than twice the number produced last year. These were obtained from 2,053 crosses and represent an over-all seed-set of 12.4 percent. Seeds were obtained from the Jersey varieties Orange Little Stem and Big Stem Jersey as both male and female parents, and from Maryland Golden, Red Jersey, and Yellow Jersey as male parents. The chief moist-flesh varieties used in crosses were P. I. 153655, P. I. 153907, L–138, and Unit I P. R. The two former were used as principal sources of fusarium resistance.

Crossing was started during the latter part of October and extended through the first part of March. Seed setting was low at the beginning and end of the season, and was highest during the month of December. Twenty percent of all crosses made during the first half of December and 23 percent of those made during the latter half were successful. The Jersey varieties Maryland Golden and Yellow Jersey were especially fertile as males, with seed-sets of 43.5 and 32.7 percent, respectively. Among the moist-flesh types, Unit I P. R., L–5, and L–138 were highly fertile as female parents, with seed-set percentages of 66.7, 50.0, and 36.4, respectively. Seeds from crosses involving Big Stem Jersey and Red Jersey have been obtained for the first time. Nineteen open-pollinated seeds from Jersey Orange, Orange Little Stem, Big Stem Jersey, and Maryland Golden also have been harvested.

The first greenhouse tests for fusarium wilt resistance on 31 F_1 hybrids between Jersey and moist-flesh sweetpotatoes have been carried out at Beltsville.[1] These hybrids, carrying one full set of Jersey chromosomes, tested as follows: Six were very resistant, 2 resistant, 8 tolerant, 6 slightly susceptible, 3 susceptible, and 6 very susceptible. These results indicate that it is possible to transfer fusarium resistance from the moist-flesh types into their Jersey hybrids.

TOMATO TESTING. H. J. Cruzado and H. E. Warmke.

Two new tomatoes, STEP 68 and STEP 89, produced by the U. S. Regional Vegetable Breeding Laboratory at Charleston, S. C., led all other introductions in the 1949 replicated trials of the Southern Tomato Exchange Program (STEP) at Mayaguez. Heavy rainfall and an unusual summer attack of late blight caused relatively poor production. Selection 48209, which is the Mayaguez introduction to this

[1] Tests conducted by C. E. Sternbauer, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering.

year's trials performed poorly. It was fifth, after leading all other STEP selections in preliminary tests last year.

Thirty-five new strains (STEP Nos. 80, 83, 101A, and 107–138, inclusive) were tested in the observational trials; and five standard varieties—Rutgers, Grothens, Red Globe, Jefferson, Stokesdale, and Lakeland—were tested in local trials this season. STEP 121, an Asgrow-Beltsville introduction, led the entire group with a production of over 30 ounces per plant.

Tomato Diseases. T. Theis.

A wilt disease of tomatoes was observed near Mayaguez in a mixed plot of commercially important varieties. Symptoms included general stunting of the plants, yellowing and ultimate loss of the leaves from the bottom up, browning of the vascular bundles, and, finally, premature death of the plants. On six occasions, isolations were made and a fusarium recovered each time. Healthy plants were inoculated (root-dip technique) with a fungus isolate, and wilt symptoms developed. From these plants the fusarium culture was reisolated. The causal organism has been identified as *Fusarium lycopersici* Sacc. This disease has not previously been reported in Puerto Rico.

The resistance of several tomato varieties to this local fusarium isolate was compared in a greenhouse test. Pan America, of known high resistance; Marglobe of known partial resistance; and Platillo, a native variety of unknown resistance, were included in the test. When the plants were in the four-leaf stage, the roots were dipped in a standardized spore mycelium suspension of the fusarium and transplanted to beds of constant soil temperature (26° C.). After 3 weeks, results were taken. This experiment indicated three levels of resistance. Platillo is the most susceptible, showing a complete, uniform wilt in 8 days. Marglobe is resistant for a time but succumbed after 3 weeks. Pan America grew vigorously throughout the test, although the fungus was isolated from several plants. The field where the disease was first observed was planted with crosses of native and imported tomato varieties including Pan America. Inoculum naturally present in the soil was depended on for infection. In spite of dry, cool weather infection was prevalent, but erratic. Some Pan America plants were infected, but in general, the vines were vigorous.

The Platillo tomato was also tested for resistance to bacterial wilt, *Pseudomonas solanacearum* E.F.S., which is prevalent in Puerto Rico and in the southern United States. The disease culture was isolated from field material, plated out twice for purity, and a virulent isolate was selected. Marglobe and Pan America, susceptible lines, were used for comparison of disease resistance. All plants were inoculated by root-dip technique and transplanted to beds of constant soil temperature (26° C.). Results taken after 21 days indicated that neither the Platillo tomato nor the tomatoes included in the comparison lines were resistant to bacterial wilt.

Papaya Breeding. H. E. Warmke and H. J. Cruzado.

A successful cross has been made, using *Carica Goudotiana* (Triana & Planch.) Solms.-Laub., a dioecious species, as female parent and *C. monoica* Desf., a monoecious species, as male. During the past season 42 plants of this hybrid have been grown at Mayaguez and at Isabela. The hybrids have grown more vigorously and set more fruits than either of the parental species. They resemble the male parent in

having oval fruits, in the low branching condition of the stem, and in the monoecious sex habit; they resemble the female parent in having light-yellow fruit color. The hybrids have leaves that are intermediate between the many-lobed leaves of *C. Goudotiana* and the three-lobed leaves of *C. monoica* and seeds with spines shorter than *monoica* but larger than *Goudotiana.* The hybrid fruits contain many seeds, but a large portion of them do not have embryos or endosperms. The filled seeds, however, are fertile, and a group of F_2 seedlings has been started.

Plants of three related species, *Carica quercifolia* (St. Hil.) Solms.-Laub., an unidentified *Carica* species (introduced as "papaya micro"), and *Jacaratia Hassleriana* Choadt, although growing under conditions at Mayaguez which produced 95- to 100-percent infection in *C. papaya* L., failed to contract "bunchy top" disease. This suggests that plants of these species may possess resistance to the disease, and numerous crosses are being made in an attempt to obtain hybrids between them and the commercial *C. papaya.*

Sweet Corn Breeding. H. J. Cruzado.

Sixty-three F_1 inbred populations of USDA–34 sweet corn, derived from selfings made last summer at this station, and 10 lines of sweet corn received from D. F. Jones at the Connecticut Agricultural Experiment Station (New Haven), were grown in the south field plots. The USDA–34 inbreds were planted on three dates in an attempt to have pollen and receptive silks ready for crossing with the Connecticut lines.

The USDA–34 inbreds grew vigorously and seem to have lost little in vigor by the first selfing. Many of them have shown striking segregations, however. USDA–34 inbreds are quite susceptible to the fall armyworm (*Laphygma frugiperda* (S. & A.)) but two lines, 49524 and 49543, appeared to have some resistance to this pest. Seventy percent of the total number of plants in these lines were free from the worm.

The Connecticut inbreds grew poorly under Puerto Rican conditions; many produced suckers and 98 percent failed to grow more than 3 feet high. Germination was very low in these inbreds. Most of those that had reached maturity produced viable pollen, but only a small number produced silks in the ears. These lines matured early in March and coincided with the last flowers of the first USDA–34 planting. Some successful crosses were made between the Connecticut inbreds and USDA–34 S_1 plants.

PLANT INTRODUCTION AND PROPAGATION

Plant Introduction. H. F. Winters and N. Almeyda.

A total of 185 introductions was received from 14 countries during the fiscal year. Of particular interest were 8 species of bamboo, 6 from the U. S. Plant Introduction Garden at Coconut Grove, Fla., and 2 from the Plant Introduction Garden at Savannah, Ga. This brings the total number of bamboo species and varieties at the station to 40. Additional introductions were ornamental, vegetable, forage, grain, nut, and other economic plants.

A variety of *Rubus glaucus* Benth. reached maturity and fruited for the first time. This tropical raspberry was grown at Toro Negro

from seed sent by Claud Hope of Turrialba, Costa Rica. The tart, purplish fruit are about 1 inch in diameter and are excellent for pies. The vigorous thorny canes need trellising to facilitate collection of the fruit. Propagation is easily accomplished by layering the cane tips.

A heavy fruit crop was produced by the "mabolo" (*Diospyros discolor* Willd.) during August and September. This tree has previously borne several crops of seedless fruit, 1 to 2 inches in diameter, and was considered to be seedless. The fruit produced this year were uniformly 3 to 4 inches in diameter, with 5 or 6 large seed. Flavor and texture of the fruit were the same as in previous years.

Distributions. H. F. Winters and N. Almeyda.

The local demand for plants has continued to be great. A total of 15,249 ornamental plants and trees was distributed during the year as well as 777 fruit trees and 55 square feet sod of *Zoysia matrella* (L.) Merr. A total of 117½ pounds of USDA–34 sweet corn seed was distributed.

Seed (282 packets) was sent to 25 countries, often in exchange for other desired species of plants. Twelve cuttings of *Piper nigrum* L. were sent to Cuba, Hawaii, and Mexico, respectively.

A total of 104 requests for tropical kudzu seed, amounting to 198 pounds, was received during the year from 20 different countries. Puerto Rico was first in number of requests with 62, and 136 pounds of seed were distributed locally. Mexico followed with 8 requests and 14 pounds of seed distributed. Other countries to which seed was distributed are Cuba, Haiti, Panama, Union of South Africa, United States, and Venezuela.

Cytological Studies with Hevea. H. E. Warmke.

In cooperation with the Division of Rubber Plant Investigations, Bureau of Plant Industry, Soils, and Agricultural Engineering, fundamental studies were undertaken at this station on flowering, pollination, and cytology of *Hevea brasiliensis* (H.B.K.) Muell. Arg. These studies are as yet incomplete, but certain preliminary results seem of sufficient interest to report at this time: (1) Macrospore and macrogametophyte formations are apparently normal and regular. Of the four macrospores that result from the reduction divisions, three degenerate, and the functional megaspore mother cell undergoes three successive mitotic divisions to form a normal embryo sac. (2) Fruits that drop after undergoing some preliminary enlargement do not contain embryos capable of dissection. Whether egg cells are unfertilized, or if fertilized, whether they remain in a dormant condition for some time, has not yet been established. (3) Beginnings of active embryo growth appear to be greatly delayed, until the nucellus and integuments have increased enormously in size and have stored large amounts of food. The final growth of the embryo is very rapid. (4) When a *Hevea* fruit does set and remains on the tree to maturity, usually all three of its ovules develop into viable seeds. This would suggest that the low fertility is not due to chromosomal difficulties. If sterility were due to chromosomal nondisjunction and unbalance, usually only one, and rarely a second or third seed, would be expected to develop within a given ovary. The fact that setting is generally an all-or-none matter in *Hevea* would suggest that possible physiological difficulties, such as failure of pollination, pollen incompati-

bility, failure of fertilization, or premature abscission, might be involved.

Studies of meiosis in the anthers of seedling trees of *Hevea* indicate that the chromosomes associate as 18 bivalents at the first meiotic metaphase. The meiotic process appears to be completely normal and regular. No cases of multivalent associations, univalents, bridges, or nondisjunction were observed. *Hevea* is thus either diploid or allotetraploid, depending on whether 9 or 18 is considered to be the basic number. Actually, this distinction is purely academic. The fact that the chromosomes associate in pairs and undergo a regular meiosis would indicate that the high sterility in *Hevea* is not caused by cytological disturbances.

HEVEA FLOWERING AND POLLINATION. H. E. Warmke.

Hevea normally has separate male and female flowers borne on the same tree (monoecious) and the male flowers open and begin to shed pollen some days before the female flowers open. As the result of studies on flowering in *Hevea*, two abnormal sex types were observed: Over 50 percent of supposedly female flowers examined from one tree were found to be bisexual. In addition to a normal pistil, these flowers bore from 1 to 5 small but functional stamens around the base of the ovary. The pollen grains produced by these anthers were normal in appearance, well filled, and took the characteristic dark stain when treated with iodine. Occasional functional bisexual flowers have been encountered also on GV 44 and GT 711 trees. Another tree was found to be monoecious, but the majority of its female flowers opened some days before its male flowers.

In an attempt to understand the cause of the low fertility in *Hevea* (often 5 percent, or less, after either hand or open pollination), stigmas of unprotected, tree-borne flowers were examined to determine whether pollination occurs, and if so, whether the amount of pollen received is adequate. Flowers which had opened 1 to 4 days previously, and which should thus have been completely pollinated, were used for the studies. It was found that the percentage of flowers having pollen in their stigmas ranged from 12 percent on one of the seedling trees to over 80 percent on flowers of clone GT 711. The number of grains observed on the stigmatic surfaces varied from 1 to as many as 59, and a large number of stigmas have fewer than 6 grains. This variation suggests that some of the poor seed set in open-pollinated flowers of *Hevea* may be due to inadequate pollination.

The natural pollinating agent or agents in *Hevea* have not been identified, although the problem has received considerable attention in the past. During the examination of many stigmas under the dissecting microscope, in the present study, two observations regarding pollinating agents were made: (1) Thrips are frequent visitors to both male and female flowers of *Hevea*, and (2) some insect, other than thrips, visits a large portion of *Hevea* blossoms. This latter insect betrays its visits by leaving minute hairs or bristles on the sticky stigmatic surfaces.

Thrips are numerous in both male and female flowers at Mayaguez, and have been observed to carry pollen grains on their bodies. Since this pollen usually is firmly fixed to the body in masses of latex, however, it is doubtful whether these insects are responsible for any major portion of natural pollination in *Hevea*.

The finding of brownish or black hairs on the sticky surfaces of many stigmas (101 of 128 stigmas in one series of counts) indicated that some other insect regularly vists *Hevea* flowers. By placing an adhesive on the petals of female flowers, several different species of insects were caught, among them a number of specimens of true midges (chironomids). These midges were found to lose hairs readily when touched to stigmas, and the hairs lost are believed to be identical with those previously recovered from stigmas. Pollen grains were frequently observed on the antennae and bodies of these insects.

Further studies showed that there is a correlation between the occurrence of the insect hairs and the presence of pollen grains on the stigmas. In one group of newly opened flowers, 44 were found to have hairs on their stigmas. Of these, 6 had no detectable pollen, and 38 had both hairs and pollen. On 33 of the latter, pollen grains were determined as being at, or near the area on the stigma where the hairs were found.

These studies indicate that at least two different species of insects enter a large portion of female flowers of *Hevea*, under conditions at Mayaguez. These are thrips and one or more species of chironomid midges. Both may carry pollen, but the midges are believed to be the more effective pollinators because of the large number of pollen grains they deposit on the stigmas. Also, judging by the rather limited capacity of the thrips for sustained flight, it is thought that they pollenize to a greater extent than do the midges from pollen of the same inflorescence. This method of pollination is known as self-pollination.

Asparagus Bean Tests. N. Almeyda.

An experiment was started to determine (1) the optimum planting distance, (2) the effect of different elevations on growth and production, and (3) the effect of season on development and yield of the asparagus bean, *Psophocarpus tetragonolobus* (L.) DC. Four distances (2, 3, 4, and 5 feet between plants) were used for the spacing trials. In all cases rows were 4 feet apart. Two harvests were made 1 year apart, the first from seed and the second from ratoons. The effect of elevation on growth and production was determined by plantings at 80, 900, and 3,000 feet above sea level. To determine the effect of season, plantings were made every 3 months starting in February.

A higher yield was obtained from plantings spaced 3 feet between plants, in rows 4 feet apart, than with the other planting distances tried. Plantings in May gave the highest yield, and the plants were more vigorous. During the dry season the plants did not reach normal height, and production was low. Plantings made at the lowest elevation (80 feet above sea level) gave best results. A planting at Las Mesas (about 900 feet above sea level) gave fair results, and at Toro Negro (about 3,000 feet above sea level) the plants were seriously stunted and consequently gave very low yields.

ENTOMOLOGY

Establishment of Introduced Beneficial Insects. H. K. Plank.

In 1935, an intensive program of introduction and colonization of the natural enemies of insect pests was initiated in Puerto Rico by the Bureau of Entomology and Plant Quarantine. Since 1937, the work

has been carried on as a regular project of the station. During this time 75 different species of insect parasites and predators, thought to be of possible benefit locally or in the continental United States, were introduced from various parts of the world. After careful elimination of all their own possible natural enemies, one or more species were colonized at suitable places in approximately 56 municipalities over the island, including Vieques. Studies of the establishment and effectiveness of these beneficial species were started this year. Recovery collections were made of susceptible stages of host insects to obtain evidences of parasitization, and the occurrence of introduced predators was observed in the field. The results thus far obtained are here set down.

Thirty-six collections of the sugarcane borer (*Diatraea saccharalis* (F.)), totaling some 5,000 larvae and pupae, were made from sugarcane, corn, and sorghum in 16 municipalities, where the 13 species of introduced parasites had been liberated to aid in the control of the borer. Only one of the introduced parasites, *Bassus stigmaterus* (Cress.)[2] has thus far been recovered, and then only in small numbers. However, the native tachina fly, *Lixophaga diatraeae* (Towns.), was found well distributed and in about half of the localities was exerting a parasitization of between 20 and 60 percent. A hyperparasite, *Trichopria cubensis* Fouts,[2] was found in one locality attacking the pupal stage of this beneficial insect. Other native parasites of the borer were a fly, *Sarcophaga lambens* Wd.,[3] and a species of nematode, both heretofore unreported from this host in Puerto Rico.

From 1935 to 1937, 15 species of parasites were introduced from Brazil, the Canal Zone, Mexico, and West Africa to help control the West Indian fruit flies, *Anastrapha mombinproeoptans* Sein and *A. suspensa* (Lw.). To study the establishment of these parasites, 26 collections of host fruits containing a total of nearly 13,000 fruit fly larvae were made in 5 of the 14 colonized municipalities and in 2 others near by. The introduced parasites, (*Pachycrepoideus dubius* Ashm., *Pseudeucoila* (*Hexamerocera*) sp., *P. Tetramerocera*) sp., and a new species of *Trichopria* were recovered in 6 municipalities. The native parasites *Ganaspis* sp. and *Opius anastrephae* Vier. were also encountered; the latter parasitized between 20 and 35 percent of the larvae in collections from 3 localities.

Some introduced species of coccinellids were found controlling various scale insects at points distant from the localities where they had originally been liberated. *Chilocorus cacti* (L.), introduced from Texas, Louisiana, and Cuba in 1937 and 1938 and liberated in 5 municipalities, was found to have spread to 15 other places scattered over the island. The reason for such wide dissemination probably is the known habit of this ladybeetle to seek heavy scale infestations and then to leave after they have reduced these infestations in size. *Egius platycephalus* Muls., introduced from Cuba in 1938, was found established in 8 municipalities. Only 2 of these were among the 10 municipalities where this species was originally liberated. At many points other species had come in and become established in their place. The ability of this coccinellid to subsist on low scale populations probably has been an important factor in restricting its spread. *Curinus* sp.

[2] Determined by C. F. W. Muesebeck, Bureau of Entomology and Plant Quarantine.

[3] Determined by C. W. Sabrosky, Bureau of Entomology and Plant Quarantine.

from Trinidad has thus far been found in only 1 municipality, although it was liberated in 3 others at the time of its introduction in 1937. *Cladis nitidula* (F.), brought in from Martinique, F. W. I., in 1938 and liberated in 3 municipalities, was found established in 2 of these and in 7 others, the greatest spread being about 14 miles. *Azya trinitatis* Marshall, introduced from Trinidad, was found in only 1 of the 13 places where it was liberated in 1936 and 1937.

Numerous larvae and adults of the coccinellid aphid predator, *Coelophora inaequalis* (F.), from Hawaii, were observed controlling infestations of the yellow sugarcane aphid (*Sipha flava* (*Forbes*)) in five of the nine municipalities where it had been colonized in 1938.

Anagyrus ananatis Gahan and *Hambletonia pseudococcina* Comp., parasites of the pineapple mealybug (*Pseudococcus brevipes* (Ckll.)), were introduced from Hawaii in 1937 and liberated at Lajas. Both species were recovered in collections made in the immediate vicinity at this point and about 3 miles to the west. These recoveries indicate that these parasites have been definitely established, and examinations made at the time of collection showed that they were continuing to be effective.

Another mealybug parasite, *Pseudaphycus utilis* Timb., was introduced from Hawaii in 1939 to control the coconut mealybug (*Pseudococcus nipae* (Mask.)), then a severe pest on avocado, guava, and many palms. Liberated during 1939 and 1940 in 10 municipalities, this beneficial insect has since spread to many locations, in some cases over distances of 10 to 20 miles. The coconut mealybug now occurs in much less abundance than formerly; hosts that used to be heavily infested now harbor at most only a few small colonies of mealybugs.

Dasyscapus parvipennis Gahan, a thrips parasite from Trinidad, was liberated at various places over the island from 1937 to 1939, and was found established on the red-banded thrips (*Selenothrips rubrocinctus* (Giard)) at four of these places 2 years later. No evidence of activity by this parasite has been seen recently, and if it is still present, its effectiveness must be very slight.

Acaulona peruviana Towns. and *Hyalomya chilensis* Macq. that parasitize cotton stainers (*Dysdercus* spp.) were introduced from Peru and liberated in the cotton-growing sections of the island and elsewhere in 1941 and 1942. Numerous collections of stainers made at or near several of these points during the past year did not reveal the presence of either of these parasites. However, a small number of what was determined as a new species of *Acaulona*[4] was reared from material from one location.

Redistribution of Parasites and Predators. H. K. Plank.

Although *Lixophaga* was previously introduced from Cuba into Los Mochis, Sinaloa, in western Mexico, it is not known to have become established. At the request of Efrén Zamorano Cruz, Unión Nacional de Productores de Azúcar, Mexico, D. F., three lots of puparia of *L. diatraeae* reared in the station insectary were sent to Mexico by air mail for colonization against the sugarcane borer at Xicotencatl, Tamaúlipas, 37 on January 4, 47 on February 14, and 76 on March 23, 1950. While accumulating for shipment these puparia

[4] See footnote 3, p. 14.

were kept in damp sphagnum moss in a refrigerator at between 10° to 11° C., the longest period being 4 weeks. From a sample of 5 puparia removed after 6 days of such refrigeration, 4 emerged normally by the end of 9 days. Reports on the first 2 shipments indicate that 74 percent of the puparia sent were received alive.

A study made at the University of Puerto Rico Agricultural Experiment Station of the contents of the alimentary tract of the edible bullfrog, *Rana catesbiana* (Shaw), showed that it feeds mostly on ants, cockroaches, spiders, millipedes, snails, and on such aquatic insects as dragonfly nymphs, the electric light bug, *Belostoma boscii* (Lep. & Ser.), and the dytiscid beetle, *Megadytes giganteus* (Castlenau). These aquatic insects are predaceous on tadpoles of both the bullfrog and the giant Surinam toad, *Bufo marinus* L., which is the most important natural enemy of root insect pests of sugarcane in Puerto Rico. Since the study indicated that the bullfrog does not eat tadpoles of the toad, *Rana catesbiana* can be considered to be at least indirectly beneficial. With the idea of aiding the multiplication of the giant Surinam toad, now thought to be decreasing in numbers in some parts of the island, redistribution of the bullfrog from the station colony was made to places in the sugarcane areas where permanent pools were available.

Bamboo Susceptibility Test. H. K. Plank.

An experiment was completed in which five ages of *Bambusa longispiculata* Gamble ex Brandis were tested for susceptibility to attack of the bamboo powder-post beetle (*Dinoderus minutus* (F.)) in comparison with corresponding ages of *B. vulgaris* Schrad. ex Wendl. The test pieces representing all ages of *B. vulgaris* sustained an average of 21.7 attacks each, and those of *B. longispiculata* sustained an average of 5.8 attacks each. The difference in infestation between the two species was highly significant statistically.

The first year's growth of *Bambusa vulgaris* was attacked to the greatest extent and the second year's growth was attacked to the least extent. There was no significant difference with respect to susceptibility of the bamboo to attack during the second and the fifth year or during the third and the fourth year. However, the two bamboo species tested differed significantly in their reactions from each other, beginning with the first year. In *B. longispiculata*, the first year's growth was attacked to the least extent, and the third and fourth year's growth to the greatest extent, but the differences between the attacks during the first and the third and the first and the fourth years were the only ones that were significant. It was concluded, therefore, that beetle infestation in *B. longispiculata* could be avoided by harvesting the first- and second-year culms, provided they possessed the physical qualities desired. However, the harvest of specimens of any of the ages tested would yield culms much less susceptible to attack than those of *B. vulgaris* of corresponding age.

At the time of exposure to infestation, the iodine spot test for starch was applied to samples of wood taken from the culms of both species. Culms of all ages of *Bambusa longispiculata* contained comparatively little starch. Those of the first and second years, that were attacked the least, contained the least amount of starch. In this respect this species resembled *Sinocalamus oldhami* (Munro) McClure and *Dendrocalamus strictus* Nees, previously tested. With

B. vulgaris, however, these tendencies were reversed; that is, all culms were fairly rich in starch and the young culms contained the most.

BAMBOO STARCH. H. K. Plank and R. H. Hageman.

The concentration of starch in freshly harvested bamboo wood indicated by the intensity of the reaction to the iodine spot test has been shown to be correlated to a highly significant degree with the attack of adults of the bamboo powder-post beetle (*Dinoderus minutus*). However, neither the results of the iodine spot test nor the number of attacks made by the beetles had ever been compared with the results of tests of the amounts of starch and other carbohydrates present in the bamboo. An experiment was, therefore, carried out to make these comparisons.

The culms used in this study varied from 1 to 5 years in age and were harvested from well-established clumps of five species of bamboo, *Bambusa longispiculata*, *B. polymorpha* Munro, *B. vulgaris*, *Dendrocalamus strictus*, and *Sinocalamus oldhami*. Carbohydrate analyses were made of freshly harvested samples that corresponded to eight arbitrary gradations in the intensity of the iodine spot test. The results of these analyses were correlated with the gradations and with the powder-post beetle infestation obtained simultaneously in like samples in a standardized cage test. It was shown that the intensity of reaction to the iodine spot test is a dependable indication of the concentration of starch in the freshly harvested wood of the group of bamboo species tested, and that within certain limits such concentration determines the intensity of infestation by adults of the bamboo powder-post beetle.

SOIL-EROSION CONTROL AND STABLE CROP PRODUCTION IN PUERTO RICO [5]

GRASS FERTILITY. H. E. Warmke and E. Vivas.

Investigations during the course of the year have centered largely on guinea grass (*Panicum maximum* Jacq.) and four of its varieties, known locally as gramalote, broad-leaf, Borinquen, and fine-leaf. Results given last year on the percentage of filled seeds shed between successive collections have been extended to include data on germination, viability of filled seeds, and viability of total seeds shed for these varieties, as well as for malojillo (*Panicum purpurascens* Raddi).

It was found that relatively high percentages of filled seeds are capable of germination (from 50 percent for regular guinea to 86 percent for gramalote) and, also, that under favorable conditions fertility in these grasses may be higher than was previously thought. The over-all fertility observed in the present studies for the varieties of *Panicum maximum* are as follows: Gramalote, 48.7 percent, fine-leaf 32.3, broad-leaf 28.0, regular 14.4, and Borinquen 4.5 percent. This figure for Borinquen would seem low in view of the remarkable ability of this variety to reseed itself in field plantings, and may be due to the presence of some hexaploids among the plants selected for these fertility tests. Of the seeds produced by *P. purpurascens* in these tests, 36.3 percent were viable.

[5] A Research and Marketing Act project carried on in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering, the Soil Conservation Service, and the Experiment Station of the University of Puerto Rico.

The tendency of the varieties of *Panicum maximum* to shed poor seeds early, observed last year, was borne out in the viability tests this year. It was found that by delaying the start of seed collection until 10 to 14 days after the first anthesis, depending on the variety, 96 to 100 percent of the total viable seeds may be recovered and the over-all fertility significantly increased. As a result of these tests it is suggested that commercial seed harvest be delayed. This will allow more of the late seeds to reach maturity without significant loss of early maturing viable seeds.

Grass Cytology. H. E. Warmke.

Cytological studies have revealed two types of Borinquen grass—one a tetraploid, with 32 somatic chromosomes (similar to the other *Panicum maximum* varieties), and a hexaploid form, with 48 somatic chromosomes. The two types are so similar that, to date, it has not been possible to distinguish them in the field. The hexaploid apparently arose from the tetraploid in our own test plots, where the two types were discovered growing side by side.

Studies of meiosis indicate that all the 32-chromosome varieties (gramalote, regular, guinea, broad-leaf, and fine-leaf) are autotetraploids, with various combinations of univalent, bivalent, trivalent, and quadrivalent associations. Chromosomal nondisjunction is common—instances of 14 to 18 and of 15 to 17 disjunctions were found at first anaphase, in addition to the normal 16 to 16. Bridges and lagging and precociously dividing univalents were not uncommon. In the hexaploid form, associations of six were found at meiosis, along with an increase in chromosomal nondisjunction and abnormality. *Panicum purpurascens* is an allotetraploid with 36 somatic chromosomes, which pair as 18 bivalents at first meiotic metaphase.

Grass Variety Comparisons. H. E. Warmke.

Open-pollinated seeds of the five varieties of *Panicum maximum* were collected in the field, and all were sown in sterile soil in seed pans in the greenhouse on May 5. Seedlings were transferred to 3-inch pots at 4 weeks of age and were transplanted to a field plot early in July. Throughout all stages of growth the plants showed remarkable uniformity within varieties and striking differences between varieties. Group differences in general growth habits, in height and diameter of stems, and in width of leaves were clearly evident to the eye. One of the striking differences was the age at which the different varieties flowered. The most delicate type, fine-leaf, began to flower at approximately 71 days of age, Borinquen at 82 days, broad-leaf at 100 days, regular guinea at 135 days, and the most robust type, gramalote, at 148 days. In every case, the plants within a variety began to flower as nearly simultaneously as it is possible to determine for such a character.

On October 14, culm, leaf, and inflorescence measurements were made on 10 mature plants, selected at random, from each variety. At the same time weights were taken of four mature plants. Analyses of variance show that differences between the varieties, in all the 10 characters studied, are highly significant (F-values are beyond that required at the 0.01-percent point). It is also of interest that the differences of the means of culm height and base in all five varieties are highly significant, as well as the differences for the means of leaf length and width, and for length of inflorescence and number of

branches. These statistically significant differences in size of the five forms grown under uniform field conditions would seem to answer those who have claimed that any observed differences in guinea grass types are not inherent, but merely the result of different environmental conditions.

No intervarietal hybrids were observed in any of these plantings, although the seed had been collected from open-pollinated plants grown in plots immediately adjacent to the other varieties. The uniformity of progenies within varieties in age at flowering, in size, and in general growth habits, as well as the failure of open-pollinated plants to form intervarietal hybrids in these tests, might well suggest that these varieties produce asexually.

LEGUME EVALUATION. R. H. Freyre and H. E. Warmke.

The replicated field experiment, aimed at testing forage production and nitrogen fixation of five superior legumes grown in combination with Merker grass (*Pennisetum purpureum* Schum. var. *merkeri*) has been continued during the past year. The results, after seven harvests from the south field and six from the rubber field, may be summarized as follows: (1) Yields of grass-legume mixtures in the south field surpassed those of either the grass or the legumes grown alone. The Merker grass-tropical kudzu (*Pueraria phaseoloides* (Roxb.) Benth.) combination has given the highest total yield to date. Next in order of yield were Merker grass-trailing indigo (*Indigofera endecaphylla* Jacq.); Merker grass-red bean (*Canavalia bonariensis* Lindley); Merker grass-velvetbean (*Stizolobium deeringianum* Bort.); and Merker grass-cowpea (*Vigna sinensis* (Torn.) Hassk.) combinations. (2) Under the poor soil conditions in the rubber field, Merker grass grown alone has yielded more forage than any of the grass-legume combinations. The Merker grass-kudzu combination is second in total yield. (3) Two observational plots of Merker grass in the rubber field, fertilized with yearly applications of 700 pounds of ammonium sulfate, outyielded all other plots in either of the locations.

Comparisons have been continued during the past year of a group of 82 species and varieties of native and introduced legumes grown in test plots at this station. Records of the behavior and growth habits of these legumes were taken. Among the annuals showing most promise are *Crotalaria juncea* L., *Indigofera hirsuta* L., *Stizolobium aterrimum* Piper & Tracy, and *S. deeringianum*. The following biennials were most outstanding: *Canavalia bonariensis*, *Crotalaria usaramoensis* R. Baker, *Desmodium intortum* (Mill.) Urb., and *Vigna vexillata* (L.) Rich. The most vigorous perennials were *Calopogonium coeruleum* (Benth.) Hemsl., *Desmodium nicaraguense* Oerst., *Dolichos lablab* L., *Indigofera endecaphylla*, *I. subulata* Vahl, and *Pueraria phaseoloides*. Further studies are under way with those species showing most promise, including studies on (1) adaptability to higher elevations, (2) toxicity and palatability, and (3) evaluation of other characters of possible value in a breeding program.

LEGUME BREEDING. H. E. Warmke.

Two plants of the "hairless" mutant of tropical kudzu were partly covered with screened cages so that self-pollinated as well as insect-pollinated seeds were produced. In addition, each of the hairless plants was crossed, as male parents, to normal hairy plants.

The hairless mutant bred true for the hairless character when self-pollinated. Branches of the same plants, growing outside the cages, produced offspring part of which were hairless and part of which possessed intermediate hairiness. When a normal hairy plant was crossed to a hairless one, in controlled hand pollinations, all the offspring had intermediate hairiness. These facts indicate that the mutant breeds true for the character when it is self-pollinated and thus could be propagated as a new variety and that the hairless character is determined by a gene or genes which are incompletely recessive to the normal.

GERMINATION OF STIZOLOBIUM SEED. H. E. Warmke and R. H. Freyre.

Uneven seed germination in *Stizolobium* species and hybrids causes difficulties in making comparative tests and in establishing uniform field plantings. Various seed treatments were tried in an effort to find one which would not injure the water-permeable types, but which would render the impermeable types capable of immediate germination. The most effective treatment proved to be one which provided for immersing the seed for 12 to 20 minutes in 50-percent sulfuric acid, washing it thoroughly in running water, and planting it in sterile greenhouse soil. This treatment did not detrimentally affect germination in the soft-coated types (velvetbean) and brought about germination of seeds of the difficult types ("pica pica" and its hybrids) in from 7 to 15 days.

FORAGE PATHOLOGY. T. Theis.

Ergot infection of guinea grass (*Panicum maximum* var. *guinea*) and gramalote (*P. maximum* var. *gramalote*) has been observed throughout the western end of the island (Isabela, Utuado, Toro Negro, Ponce, Lajas, Mayaguez, etc.). This disease affects the flowers and has two stages: (1) Sphacelial, characterized by an exudate from the caryopsis of spores in a sugary matrix; and (2) sclerotial, characterized by the growth of a hard fungus body out of the caryopsis. The ergot infection in most of the areas investigated appears to be scattered and endemic. The sphacelial stage is the more common. The most severe infection has been observed in the southwestern dairy region, where it may be so severe that nearly every plant in an extensive field is infected. A secondary fungus parasite on the ergot, which probably reduces the volume of the sclerotial stage, has been observed.

Farmers throughout the area were contacted to determine whether there was a correlation between the number of abortions among their animals and the extent of ergot infection in these grasses, but no authentic information could be obtained. The feeding habits of the animals in the field were found to be such that the toxic sclerotial bodies of the fungus were generally not consumed, and at present animals suffer no apparent harmful effects. However, changes in harvest practices, such as the cutting, storage, and feeding of infected hay, might result in ergot poisoning.

Ergot has also been observed on other major grasses. The sphacelial stage of the disease was found on molasses grass (*Melinis minutiflora* Beauv.) and malojillo (*Panicum pupurascens*) at Mayaguez and on molasses grass at Utuado. The failure of crops to set seed in these regions may be due to the prevalence of this disease.

ESTABLISHING A COOPERATIVE NATIONAL RESEARCH PROGRAM TO DEVELOP PRACTICAL METHODS AND EQUIPMENT FOR WEED CONTROL [6]

PERSISTENCE OF SODIUM TRICHLOROACETATE. A. J. Loustalot and R. Ferrer Delgado.

Experiments were conducted to study the effect of temperature, soil moisture, and soil texture on the persistence and movement in the soil of sodium trichloroacetate (TCA), a promising new herbicide.

Flats of soil treated with 0, 30, 60, and 90 pounds per acre of TCA were stored for 0, 2, 4, and 8 weeks under various experimental conditions before being planted to corn and pigeonpeas. The growth data showed that TCA toxicity persisted longer at the higher rates of application and for at least 2 months at 10° C. On the other hand, toxicity disappeared entirely after 2 weeks' storage at 45°.

TCA toxicity did not decrease after crops had grown for 2 months in air-dry soil, whereas it had almost completely disappeared after they had grown for 1 month in a saturated soil. Two months were required before toxicity decreased in soil with a medium moisture content.

TCA persisted longer in clay soil than in sand or the sand-clay mixture, but persisted about the same length of time in sandy soil and in the sand-clay mixture.

Certain phases of the weed-control experiments were also carried out under field conditions to determine the practical significance of the results obtained in the greenhouse. The results of the field trials were in general agreement with those obtained in the greenhouse. In the course of the field trials TCA was found to be more effective in controlling nutgrass (*Cyperus rotundus* L.) when it was applied to young growing plants than it was when applied to freshly plowed ground. Four months after treatment, plots given as little as 30 pounds of TCA per acre were practically free of all perennial grasses and nutgrass.

MOVEMENT OF TCA AND 2,4–D IN SOIL. A. J. Loustalot, T. J. Muzik, and H. J. Cruzado.

In a field experiment made to study the movement of TCA in soil, it was found that when there was no rainfall following application of the herbicide, TCA moved only into the surface inch of soil. When the equivalent of ¼ inch of rainfall was applied the TCA moved down to about 5 inches below the surface, and when 1 inch of rainfall was applied it moved down to at least 8 inches below. Although considerable leaching into the soil took place when 1 inch of water was applied, enough of the TCA remained in the first 2 inches of soil to greatly inhibit germination and growth of corn.

A similar experiment carried out with sodium 2,4–D showed that 2,4–D did not move beyond the surface inch of soil and very little moved beyond the first half inch. This may be accounted for by a chemical reaction in which the soluble sodium 2,4–D is changed to the insoluble calcium salt or/and adsorption by the soil particles.

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[6] Project carried on under the Research and Marketing Act in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering.

2,4–D Movement in Nutgrass. T. J. Muzik and H. J. Cruzado.

It is an accepted fact that auxin naturally produced from the terminal bud inhibits the growth of the axillary buds on the stem below in many plants. An experiment was conducted to determine whether a similar inhibition exists within the tuber system of nutgrass. The effect of 2,4–D application on root and shoot growth was also studied.

Nutgrass tubers, singly and in chains of 2 to 14, were planted in boxes with slanting glass sides covered with removable wooden shutters. The tubers were placed against the glass, so that formation of shoots and roots could be observed in its earliest stages without disturbing the plants. Some of the tuber chains were treated with 2,4–D and some were not treated.

These experiments showed that sprout formation was naturally inhibited in the lower tubers, presumably by the transfer of auxin from the highest tuber. The test indicates that auxin is transferred in nutgrass in a manner similar to that in which it is transferred in dicotyledonous plants. This auxin transfer takes place in the rhizome since it is the only connecting link between tubers.

Root formation was not inhibited by 2,4–D even in the larger tuber systems. This presumed inhibition by auxin does not affect root formation, although it does inhibit sprout growth. Since even the tubers to which 2,4–D was applied produced roots, it is evident that the roots are much less sensitive to growth regulators than are the shoots.

There were no leaves and therefore there was no photosynthesis in the tuber systems treated with 2,4–D and yet the roots on the lower tubers were progressively killed over a lengthy period. This indicated that 2,4–D can move in the rhizome and in other ways than with the photosynthate.

Field Test With Herbicides. A. J. Loustalot and R. Ferrer Delgado.

Recent experiments at this station and elsewhere have shown that the trichloroacetates are effective in eradicating or controlling grass weeds. An experiment was carried out to test the efficiency of sodium trichloroacetate (TCA) in controlling grasses in newly planted cane fields and to determine the tolerance of the sugarcane to the herbicide.

Sodium TCA at the rate of 100 pounds per acre was sprayed on plots prepared for planting. One plot was planted with sugarcane immediately after spraying and the other plots were planted 1, 2, 3, and 4 weeks after spraying.

The sugarcane "seed pieces" in all plots germinated almost 100 percent and there was no apparent deleterious effect of the TCA on the cane even in plots where it was planted immediately after treatment. Cane germination in the check plots was poor, apparently brought about by heavy weed competition.

Six months after treatment treated plots were practically free of perennial grasses whereas check plots were heavily infested with these weeds. Twice during this period both treated and check plots were sprayed with 0.2-percent 2,4–D isopropyl ester to control broadleaf weeds such as *Commelina* sp., *Ipomea* sp., and nutgrass.

The results of this experiment indicate that TCA used as a preplanting treatment will kill or hold in check most of the grass weeds and when used in combination with 2,4–D sprays will control almost all of the weeds that develop before the cane closes over.

The effect of time of application on weed control was studied with TCA and Nalco contact herbicides. One group of plots was sprayed with Nalco and the other group with TCA immediately, and 1, 2, 3, 4, 6, and 8 weeks after plowing. The Nalco was applied at the rate of 1 gallon per 1,500 square feet, and the TCA at the rate of 100 pounds per acre. Records on the relative stand of weeds were made at 1- to 2-week intervals over a period of 11 weeks. The Nalco was of no apparent value in controlling weeds when it was applied immediately or 1 week after plowing. When it was applied 2 or 3 weeks after plowing the weeds had grown considerably and were controlled more or less satisfactorily for a period of about 6 weeks thereafter. When the Nalco was applied later than 3 weeks after plowing, weed control was not satisfactory. At this time the weeds were well developed and the quantity of Nalco applied was insufficient for adequate coverage. This experiment indicated that the optimum time to apply Nalco at the rates used is when the weeds are about 4 to 6 inches high.

TCA applied immediately after plowing did not control the stand of weeds appreciably. When it was applied 1 and 2 weeks after plowing, the stand of weeds was effectively controlled for several weeks thereafter. The applications made 3 and 4 weeks after plowing were about equally effective in reducing weed population and the suppression continued somewhat longer than that of applications made earlier or later. TCA applied 6 and 8 weeks after plowing was only partially effective. By this time the weeds were well established and the TCA could not penetrate the soil in amounts lethal enough to kill the roots. This experiment indicated that the most effective time to apply TCA is when the weeds have germinated and started to grow.

Two formulations of Nalco—Nalco H–172 and Nalco H–176—were tested in preliminary trials. Both of these materials have an oil as a vehicle and are general contact herbicides. H–176 is supposed to be particularly effective for control of perennial grasses.

The materials were sprayed along roadside and ditch banks around the station grounds and in fields heavily infested with broadleaf and grass weeds. Both herbicides killed all vegetation on which it was sprayed, including the hard-to-eradicate water fern, *Salvinia rotundifolia* Willd. The formulation H–176 seemed to be somewhat more effective than the H–172. Sprayed vegetation remained brown for a period of 6 weeks following application even though several heavy rains fell shortly after.

Preemergence and preplanting trials conducted with the Nalco formulations showed that they are not effective when applied in this manner, but that they are very effective when applied as contact herbicides to young growing vegetation.

Tests on Bermuda Grass With 2,4–D and Geon. A. J. Loustalot and R. Ferrer Delgado.

Plots of Bermuda grass (*Cynodon dactylon* (L.) Pers.) were treated with a solution of 2,4–D at 1,000 or 2,000 parts per million (p. p. m.) alone or with Geon latex at 25 percent. Within a week after the treatments, the Bermuda grass sprayed with 2,000 p. p. m. of 2,4–D and 25 percent Geon was discolored and dying, and plots sprayed with 1,000 p. p. m. and 25 percent Geon showed similar symptoms but to a lesser degree. None of the other plots showed signs of injury.

The Geon–2,4–D combination was more effective when the Geon was

applied first, allowed to dry, and then followed by the 2,4–D. Applying the combination in reverse order or at the same time appeared to be less effective.

The results of this test indicated that the addition of Geon latex to 2,4–D is an effective herbicide on Bermuda grass.

GREENHOUSE STUDIES WITH TCA. A. J. Loustalot and R. Ferrer Delgado.

Field experiments on the control of nutgrass with TCA applications have given erratic and inconclusive results. Since soil moisture levels, depth at which tubers are located in the soil, number and physiological conditions of tubers, and many other factors vary widely within relatively small areas, it is not surprising that results of field experiments are sometimes difficult to interpret. An experiment, designed to study the effect of depth of planting of nutgrass and treatment with TCA, was carried out under greenhouse conditions where environmental factors could be better controlled.

Nutgrass tubers were planted in containers at 1, 2, 4, 6, 8, 10, 12, 15, 20, 25, 30, and 35 inches below the soil surface. One group of jars was treated with sodium TCA at the rate of 100 pounds per acre and another group remained untreated. After the treatments were applied and at intervals of 1 week, or as needed, all the jars were watered with the equivalent of one-fourth inch of rain with a sprinkling can. Emergence counts and other data were taken at 5, 8, 12, 18, 24, 37, 60, and 133 days after the tubers were planted.

The results of this experiment indicate that mature nutgrass tubers germinate and about 100 percent of the young seedlings emerge even when the tubers are located 15 inches below the surface of the soil. However, the time required for emergence was directly correlated with the depth at which the tubers are located in the soil. When the tubers are located 20 inches or deeper below the surface the emergence of young seedlings was greatly inhibited, but 2 to 6 percent of the tubers emerged 37 days after planting, and this is probably enough eventually to infest an area. Treatment of the soil surface with sodium TCA at 100 pounds per acre inhibited the growth of tubers planted at all depths for a period of 90 days, but at the end of 133 days 6 to 56 percent of the tubers (i. e., buds on tubers) had germinated and produced seedlings when the depth of planting was from 1 to 15 inches. During this period the TCA had been either leached or inactivated and apparently some buds on some tubers were still alive. The data obtained in this study help to explain some of the erratic results obtained in field trials.

Another experiment was carried out to obtain additional information on the effect of TCA on germination of nutgrass tubers. Mature tubers were selected from a field collection, divided into 77 lots of 30 tubers each, and immersed for 5, 10, 20, 40, 80, 160, and 320 minutes in solutions of sodium TCA of the following concentrations: 0, 10, 50, 100, 190, 380, 750, 1,500, 3,000, 6,000, 12,000 p. p. m. After treatment the tubers were planted in tin cans containing moist soil. Counts of young seedlings were made 5 weeks after the tubers were planted.

Germination of tubers was somewhat inhibited by immersion in the TCA solution, particularly at the high concentrations and at the long exposures, but in no instance was germination completely inhibited. The practical implications of this experiment are obvious. When TCA is applied in the field, it causes an initial reduction in the stand

of nutgrass. This is the result primarily of the toxic action of the herbicide on the stem, leaf, and bud portions of the plants. As long as lethal concentrations of TCA remain in the soil, new plants which arise from buds on the tubers are killed. However, when the toxicity of TCA disappears through leaching or inactivation, one or more live buds usually remain on the nutgrass tubers, and these germinate and reestablish the stand. Ordinarily TCA is applied at the rate of 100 pounds per acre. If this amount is uniformly distributed in the surface 6 inches of soil, the concentration of TCA would be about 50 p. p. m. In the present experiment, exposure of the tubers to a concentration of 12,000 p. p. m. for over 5 hours did not kill all the buds on the tubers.

Cogon Grass Eradication. A. J. Loustalot.

Seed or stolons of cogon grass (*Imperata cylindrica* Beauv.) were introduced into Puerto Rico in late 1940 or early 1941 by the U. S. Soil Conservation Service. The material came from Florida, probably from the area around Brooksville, and was received by members of the Soil Conservation Service stationed at Mayaguez at that time. Three or four small plantings were made in gullies and areas in Las Ochenta on Federal Experiment Station land at that time under the control of the SCS. Later a planting of cogon grass root clumps was made in a gully on the farm of Pedro Bras near Mayaguez. The SCS was advised that cogon grass might become a dangerous pest and a determined but unsuccessful effort was made to dig it out and eradicate it by mechanical means and burning. Cogon grass has not flowered under Puerto Rican conditions until recently, and for that reason it has probably not escaped over the island. However, it has spread considerably from the areas on which it was originally planted. Some of the grass flowered in May 1950 following a fire, and the danger of spread is ever present. In September 1949 the SCS requested the cooperation of this station in eradicating this pest with chemical weed killers.

The grass was cut or mowed back to a 4-inch stubble. This stubble was sprayed with Nalco contact herbicide. After 3 or 4 days the dried stubble was burned. A solution of sodium trichloroacetate (TCA) at the rate of 100 pounds per acre was then applied to the exposed soil. With the exception of a few spots in one or two of the treated areas the cogon grass appears to have been eradicated or at least suppressed for the time being, 5 months after treatment.

Weed Control Practices. A. J. Loustalot.

A wide variety of contact and selective herbicides have been tested on many weed species and under varying environmental conditions. Chemical weed killers offer a practical defense against weeds. Among the factors to be considered in the station's weed control investigations are: (1) Control of nutgrass in corn, experimental forage grasses, sweetpotatoes, and legume test plots; (2) preemergence control of weeds in cotton; (3) control of the pond fern, *Salvania* sp.; and (4) control of cogon grass, *Imperata cylindrica.*

The practical application of chemical weed-control methods reduced the amount of hand labor required to maintain experiments. In many instances chemical weed control was more efficient. Useful incidental information was obtained, also, as records on labor, time,

rates, and efficiency were kept in the investigations on each weed problem.

VANILLA

VANILLA SPECIES. F. A. Jiménez and A. J. Loustalot.

Vanilla fragrans (Salisb.) Ames, the source of commercial vanilla, is highly susceptible to attack of the root rot organism, *Fusarium batatatis* var. *vanillae* Tucker. This disease is one of the important limiting factors in the production of vanilla in Puerto Rico and elsewhere. There are several other species of vanilla which are of little economic value but which appear to be resistant to the disease and thus offer a source of good germ plasm in developing resistant hybrids. To compare the relative resistance of some of the most promising species, cuttings of *V. barbellata* Reich., *V. pompona* Schiede, *V. phaeantha* Reichb. f., and *V. fragrans* were planted in a forest vanillery in a mulch which had been inoculated with cultures of the disease organism. Three years later, data on growth and survival were obtained. *V. phaeantha* was the most resistant species tested and *V. fragrans* the most susceptible. The two other species were intermediate in susceptibility.

VANILLA PATHOLOGY. T. Theis and F. A. Jiménez.

Two techniques were developed to measure the resistance of vanilla plants to vanilla root rot: (1) Holdfasts of *Vanilla fragrans* were freed from the supporting stake and were surface-sterilized, inserted in tubes of sterilized soil, and watered with distilled water. The holdfasts developed into vigorous roots in 6 weeks. The vanilla root-rot fungus was added to the tubes (chopped agar culture), and typical disease symptoms developed. In some cases the disease progressed through the holdfast and into the internode. This was checked by reisolation of the fungus from the internode. (2) Two-node cuttings of four varieties of vanilla, *V. fragrans*, *V. phaeantha*, *V. pompona*, and *V. barbellata*, were surface-sterilized and planted with one node (leaf removed) below the sterilized cocopeat mulch. At the end of 6 weeks, root growth measurements were taken. This method provided homogeneous material for inoculation purposes in a relatively short time. The main advantage of this technique is that small plants of different species can be grouped together in single flats for comparative studies under uniform conditions.

The vanilla root-rot fungus, *Fusarium batatatis* var. *vanillae*, isolated in pure culture from plants of *Vanilla fragrans* was grown on buffered media with adjusted pH ranging from 2.0 to 11.0. No growth was made at pH 2.0. The growth gradually increased as the pH increased until an optimum of 6 and 7 was reached, after which the growth declined as pH increased to 11.0. Even at this high alkalinity the fungus made fair growth. This experiment indicates that in culture the root-rot organism has an optimum pH for growth but is more tolerant of alkaline reactions than of acid.

SOIL MOISTURE STUDIES. F. A. Jiménez and A. J. Loustalot.

An experiment was conducted under greenhouse conditions in which vanilla vines were grown in high, intermediate, and low soil moisture. After 18 months under treatment, the vines were harvested and growth measurements, which included length of vines and fresh and dry

weights of plant parts, were obtained. The best shoot growth was made by vines grown in the plots with intermediate moisture. Slightly, though not significantly, better root growth was made by plants in the high-water treatment. In general, the dark green and turgid plants in the intermediate-moisture plots were the best in appearance. Those in the low-water plots were chlorotic, wilted, and similar in appearance to plants suffering from drought or disease in the field. Plants in the high-moisture plots were intermediate in appearance between those growing in the other two treatments.

The results of the experiment indicate that low soil moisture is more detrimental to growth of vanilla vines than high soil moisture, but that the best growth is obtained when soil moisture is intermediate.

BAMBOO

DISTRIBUTIONS. F. Montalvo Durand.

The Insular Forest Service continued to cooperate with the station in the planting of newly introduced bamboos in connection with their watershed protection program. During this year 250 clump divisions of *Bambusa tulda* Roxb., 1,500 *B. tuldoides* Munro, 800 *Gigantochloa apus* (Roem. & Schult.) Kruz ex Munro, and 100 *B. textilis* McClure were supplied to the Forest Service. In cooperation with the Soil Conservation Service the station supplied 1,000 clump divisions of *G. apus* and 100 *B. longispiculata* Gamble ex Brandis, to private individuals.

PROPAGATION STUDIES. F. A. McClure [7] and F. Montalvo Durand.

A series of experiments was initiated in an effort to find a satisfactory means of producing large numbers of small rooted plants of selected species of bamboos. Special stress was laid on economical methods of obtaining material, handling labor, and transporting plants to new planting sites. Experiments were conducted in propagating bamboo by stump layers, whole culm cuttings, rhizome cuttings, and branch cuttings. The propagating media used were cocopeat and a 1 : 1 mixture of cocopeat and a fine river deposit called "basa."

Stump layers were prepared by cutting all of the culms of a clump above the second culm node, applying indolebutyric acid in cocopeat to the branch bases on one-half of each clump, and then covering the whole with 1 : 1 cocopeat and basa. This method was successful only with *Bambusa longispiculata*, and the experiment is being continued with this species, without the indolebutyric acid, which was of no apparent value. Unfavorable results with *B. textilis*, *B. tulda*, *B. tuldoides*, and *Dendrocalamus strictus* Nees have led the station to discontinue the stump-layer method of propagating with these species for the present.

Promising results have been obtained in the propagation of *Bambusa tulda* and *Dendrocalamus strictus* by means of whole culm cuttings. The distal one-fifth of the culm was cut off, the small branches at each node were cut back to about 1 inch, and the main branch at each node was cut off just above the node termianting the first elongated internode. The culms were then buried in a horizontal position, to a depth of about 4 inches in the propagating medium, the interval between

[7] Technical Collaboration Branch, Office of Foreign Agricultural Relations, U. S. Department of Agriculture.

culms being about 1 foot. The exepriment is being continued, with other species, also.

In many clump bamboos, the rhizomes tend to develop on or near the surface of the ground. In preparing cuttings, each rhizome is severed once at the proximal end by cutting through the narrow neck just above the point of origin, and again at the base of the culm distal to it. The roots are trimmed to produce a flat surface in a horizontal plane so that the rhizome will assume its normal orientation when placed on the ground. The whole rhizomes are then arranged in close order in a sunny location with good drainage, and covered to a depth of 3 or 4 inches with propagating medium. One problem with which investigators have been confronted in the propagation of bamboo by rhizome cuttings is the persistent dormancy in the basal buds. Experiments aimed at overcoming this dormancy and now is progress with *Bambusa longispiculata*, *B. textilis*, *B. tulda*, and *B. tuldoides*.

Branch cuttings of *Bambusa longispiculata*, *B. textilis*, *B. tulda*, *B. tuldoides*, *B. ventricosa* McClure, *Gigantochloa apus*, and *Dendrocalamus strictus* were planted obliquely in 1 : 1 cocopeat and basa, the base of each cutting at a depth of about 3 inches, and only the uppermost buds were exposed. With this method, the greatest degree of success in preliminary trials was achieved with *G. apus*.

Fertilizing Bamboo. F. Montalvo Durand.

A fertilizer experiment was completed in which clumps of several species of bambo, *Bambusa tulda*, *B. longispiculata*, *B. tuldoides*, *B. textilis*, *Dendrocalamus asper*, *D. strictus*, and *Sinocalamus oldhami*, were fertilized annually with 2 pounds of 12–10–6 fertilizer per clump. There was a consistent increase in growth in the fertilized clumps of all species except *B. longispiculata*. *B. tulda* and *S. oldhami* clumps responded best to the fertilizer.

An experiment was started in October 1947 to observe and measure the effect of annual applications of ammonium sulfate, superphosphate, potassium chloride, and filter press cake on the growth of *Bambusa tulda*.

Growth measurements and the number of new fully developed culms produced during the past year showed that bamboo responded best to application of ammonium sulfate.

Spacing Bamboo. F. Montalvo Durand.

In April 1946 a planting of *Bambusa tulda* was made at three different spacings: 15 x 15 feet, 20 x 20 feet, and 25 x 25 feet on the square on a Mucara silty clay loam at Cidra. The object of this experiment was to determine the most desirable planting distance for this species.

The results to date indicate that the optimum planting distance for bamboo must depend on the purpose for which it is planted. If large well-developed culms are desired, the clumps should be planted rather far apart. If large numbers of relatively smaller culms are desired the clumps should be planted closer together.

COFFEE

Agronomic Studies. A. Rodríguez Cabrera and S. Rodríguez Ortiz.[8]

The yields of the Columnaris and the Puerto Rico varieties of coffee (*Coffea arabica* L.) were compared for the sixteenth consecutive year

[8] Experiment Station of the University of Puerto Rico.

in the experiment established at the station farm. The Columnaris variety yielded at the rate of 5.68 hundredweights of marketable coffee per acre while the Puerto Rico variety yielded 4.72 hundredweights per acre. This difference was not significant. The average yield per acre of the Columnaris variety for the 16-crop period has been 10.74 hundredweights of marketable coffee as compared with 5.94 hundredweights yield of the native variety. This difference was highly significant.

WEATHER

RAINFALL WAS BELOW AVERAGE FOR THE FISCAL YEAR 1949–50.

The rainfall for the last 6 months of 1949 was 49.12 inches, or 0.81 inch below the 51-year average. For the first 6 months of 1950 the rainfall was 19.69 inches, or 10.00 inches below the 52-year average. Only July and February had average or above-average precipitation. The rainfall for the remainder of the year was below average. The total rainfall for the fiscal year 1949–50 was 68.81 inches, or 10.81 inches below the 51-year average of 79.62 inches.

The mean temperature record at Mayaguez, P. R., for the fiscal year 1949–50 was 77.27° F., which was only 0.02° below the 51-year average of 77.29° F. The complete weather details are given in table 1.

TABLE 1.—*Weather conditions at the Federal Experiment Station, Mayaguez, P. R., during the fiscal year 1949–50*

Month	Precipitation [1]			Temperature [2]				
	Total	Greatest in 24 hours	Days with 0.01 inch or more	Mean maximum	Mean minimum	Mean	Maximum	Minimum
1949	*Inches*	*Inches*	*Number*	°F.	°F.	°F.	°F.	°F.
July	13. 96	1. 50	19	90. 0	68. 6	79. 3	93	66
August	9. 86	1. 28	22	90. 9	69. 8	80. 4	94	67
September	9. 87	2. 36	18	90. 5	71. 0	80. 8	95	65
October	9. 19	1. 79	14	89. 3	68. 4	78. 9	92	66
November	3. 95	1. 67	15	87. 3	67. 2	77. 3	91	65
December	2. 29	. 50	13	84. 5	65. 5	75. 0	88	62
1950								
January	. 61	. 21	6	82. 6	63. 9	73. 3	86	59
February	3. 48	1. 39	8	83. 6	63. 9	73. 0	86	60
March	1. 91	. 62	10	85. 3	62. 5	73. 9	89	59
April	2. 58	. 83	11	86. 5	63. 9	75. 2	92	61
May	4. 84	1. 64	11	89. 4	66. 4	77. 9	93	62
June	6. 27	2. 25	12	90. 1	68. 3	79. 2	93	62

[1] 51-year average: July, 10.51 inches; August, 10.95 inches; September, 10.77 inches; October, 9.26 inches; November, 5.89 inches; December, 2.55 inches.

52-year average: January, 2.00 inches; February, 2.04 inches; March, 3.68 inches; April, 4.92 inches; May, 8.24 inches; June, 8.81 inches.

[2] 50-year average—Mean temperature: July, 79.0°; August, 79.4°; September, 79.4°; October, 79.2°; November, 77.6°; December, 76.0°.

51-year average—Mean temperature: January, 74.6°; February, 74.8°; March, 74.9°; April, 76.1°; May, 77.8°; June, 78.7°.

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RESEARCH ACHIEVEMENT SHEETS

R. A. S. 91 (o)—A quick, simple method for quinine analysis of Cinchona bark. May 1948.

R. A. S. 92 (o)—Tropical kudzu a promising legume for the American Tropics. May 1948.

R. A. S. 97 (o)—New quick method gives accurate estimate of the insecticidal value of Derris root. July 1948.

R. A. S. 115 (o)—Guppies used in assaying insecticidal value of rotenone-bearing roots. January 1949.

R. A. S. 118 (o)—A toad serves the sugar industry of Puerto Rico. January 1949.

R. A. S. 122 (o)—Introduced grasses and legumes play important double role in Puerto Rico. August 1949.

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